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ABSTRACT

As an input to projections of sub-national populations by ethnicity, this paper develops the first estimates of the mortality risks experienced by the UK ethnic groups. Two estimates were developed using alternative methods. In the first, UK 2001 Census data on limiting long-term illness to predict mortality levels and regression equations between local Standardized Illness and Mortality Ratios for all ethnicities are assumed to apply to individual ethnic groups. In the second, the geographical distribution of ethnic groups by local areas is combined with local mortality for all ethnicities to estimate national mortality rates by ethnicity, which are then employed to estimate local ethnic mortality. A comparison of the two estimates indicates that the method based on illness rates produces more plausible outcomes. The local SMRs produced for each ethnic group were used to generate ethnic group life tables for 432 UK local authority areas in 2001, which included estimates of survivorship probabilities by single year of age, gender and ethnic group for each local area for use in a projection model.

Keywords:
Ethnic mortality estimates
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Local Authorities
United Kingdom
**Introduction**

Two dominant trends affected the UK population in the period since the Second World War. The first was continued population ageing, as a result of declining and low fertility and steady improvement in life expectancy, especially at older ages in recent decades (Dunnell 2008). Population ageing was delayed and reduced by the baby boom of 1945-1970 but when these cohorts reach old age over the next quarter century ageing will be enhanced. During the 1950s and 1960s, when the smaller cohorts of 1925-1945 entered the work force, labor shortages led to immigration from both other European and extra-European countries. After a hiatus in the 1970s and 1980s, net immigration grew steadily in 1990-2008. The main demographic consequence of sustained international migration into a country is the growth of the population of immigrants and their descendants. If the native population is growing slowly, the ethnic composition of the population will change. This, in turn, leads to changes in national identity and culture. Coleman (2006a, 2006b) has labelled this sequence of events the 'Third Demographic Transition'.

Countries need to have a view of the future ethnic composition of the national population, which is likely to change substantially over the next 50 years. What demographers normally do to explore the future is to carry out projections of the population. These projections take into account the age and sex structure of the population and its spatial distribution at country, region and local levels (ONS, 2008a; ONS & GAD, 2006; ONS 2004a). Projections of the England and Wales population by ethnicity have been carried out (reviewed later) but are not currently included in the official projection series.

Why might we want to project the population of the UK’s ethnic groups? The first reason is that if demographic intensities (rates or probabilities) vary across population sub-groups, then that heterogeneity (for evidence see Office for National Statistics 2004b) needs to be built into projections. The second reason is so that we can monitor equality of opportunity across ethnic groups, assess future labour supply in terms of size and skills and ensure schooling and other public services are adapted to a multi-ethnic population.

There are a number of challenges involved in ethnic population projection. These include the definition of ethnicity, the degree to which ethnic groups can be projected separately and how the fertility, mortality and international and sub-national migration assumptions should be prepared. One missing ingredient from previous projections of the UK population by ethnicity is an absence of knowledge about ethnic group mortality. The principal aim of this paper is to fill that gap by developing a method for estimating ethnic mortality.
The organization of the paper is as follows. The second section of the paper reviews work on projecting ethnic group populations in the UK and elsewhere and work on the ability of self-reported health to predict mortality for individuals and for geographical populations. The third section of the paper describes the data sets used in the current study. The fourth section outlines the method for ethnic mortality estimation that uses information on limiting long-term illness. The fifth section describes a method which re-weights local area mortality by the ethnic composition of the local population. After a comparison of the two methods, the sixth section selects a preferred method, the illness-mortality method and describes the principal results. The final section summarizes and evaluates the findings of the paper.

Background

*Are ethnic-specific mortality rates used in population projections?*

Many national statistical agencies carry out population projections for the racial/ethnic groups that compose their national populations. The US routinely computes projections by race and Hispanic origin (US Census Bureau 2008) and publishes life expectancies by race (NCHS 2007). These reveal considerable differences: Black Americans had 5.5 fewer years of expected life than White Americans in 2003, for example, while the difference between Pakeha (European origin) and Maori life expectancies was 8.5 years (Statistics New Zealand 2008). Coleman (2006b) reports that European countries mostly use a nationality or country of birth based groups and use group specific mortality data. So, best international practice is to collect mortality data by race/ethnicity directly on the death records and to incorporate ethnic-specific mortality into ethnic group projections.

The United Kingdom has a history of ethnic population projections (Storkey 2002a, 2002b; Rees and Wohland 2008, Table 1). In the 1970s the Office of Population Censuses and Surveys carried out projections of the population born in the New Commonwealth and Pakistan (OPCS 1977a, OPCS 1997b, 1979). This was extended to five broad ethnic groups using 1981 Census data (OPCS 1986a, 1986b). No official projections have been implemented using 1991 and 2001 Census data on ethnicity, but detailed estimates for 2001 to 2007 for local authorities in England have been made using 16 ethnic groups in the 2001 Census (Large and Ghosh 2006a, 2006b). Many projections for individual local authorities have been produced using 1991 Census data (Bradford 1999, 2000) or the 2001 Census (Simpson and Gavelas 2005a, Danielis 2007). Local projections have also been made for the Boroughs of Greater London building on work by Storkey (2002a), using the 1991 Census for base populations (Hollis and Bains 2002) and 2001 Census populations (Bains and Klodawski 2006, 2007). A UK level projection for four
broad ethnic groups incorporating innovative features (e.g. probabilistic forecasts) has been implemented by Coleman and Scherbov (2005). Finally, projections using five summary ethnic groups for 13 UK regions were produced by Rees and Parsons (2006). However, none of the UK projections so far carried out employ ethnic specific mortality rates.

The measurement of ethnic mortality in the UK

Why should this be? The fundamental reason is that, to date, ethnic status has not been recorded in the UK’s death registers. A start has been made. Infant mortality rates for 2005 have been computed by ONS by matching birth and infant death registration records with NHS numbers for babies records which include information on ethnic group (ONS 2008b). Country of birth is entered on death records but this captures only the experience of the first generation of immigrants. Harding and Balajaran (2002) have reviewed the data sources available and their shortcomings. They have matched deaths by country of birth with populations at risk from the 1971, 1981 and 1991 Censuses but the groupings are broad (e.g. Indian sub-continent) and the estimates are confined to first generation immigrants. Bias is present in the “Born in India” group, which includes White British people born in India before independence in 1947. There is evidence that mortality experienced by second and subsequent generations is worse than that experienced by first generation. Harding and Balajaran (2002, Table 10) apply hazard analysis to all cause mortality of first and second generation ethnic groups aged under 65 at the 1991 Census and followed through to 1997. Hazard ratios (ratios to the mortality risk experienced by Whites born in the UK) range from 0.64 to 0.84 for the first generation of Indians, Pakistanis, Bangladeshis, Black Caribbeans and Black Africans but are between 1.28 and 1.85 for all but one second generation groups.

A more promising data source in England and Wales is the Longitudinal Study (LS), a 1% sample of linked records from the past four censuses (1971-2001). Ethnicity was measured in a direct question in the 1991 Census and in the 2001 Census. People in the LS are linked to the deaths register so that the mortality of each ethnic group member can be identified, as long as sample members have not left the UK. So, you need to wait for the next census to identify survivors and non-survivors. Harding and Balajaran (2002) report up to 30% loss to follow-up of LS members, mainly as a result of emigration. Return migration to the Caribbean is common at retirement. A high degree of return migration biases the measurement of mortality risk. If return migrants are healthier than non-migrants, this will raise the mortality rates of those left in the sample. If return migrants are less healthy than non-migrants, this will reduce the mortality rates of those left behind. They may be counted in the mortality rate denominator but are absent from the deaths numerator (see Boyle and Norman 2009 for a review of this “salmon” effect).
The relationship between self-reported health and mortality for individuals

So, what can be done to fill this gap in UK demographic statistics? We need a data source that can deliver reliable ‘proxy’ information on mortality for all of the ethnic groups at local level. That source is the set of tables on self-reported illness for local areas generated from the 2001 Census, which asked questions on “limiting long-term illness” (similar to that asked in 1991) and on “general health”. The question is then whether illness or health data collected from a census can be used to estimate the mortality risks of a local population. There have been a large number of studies carried out using data from the USA (McGee, Liao, Cao & Copper 1999; Franks, Gold & Fiscella, 2003; Singh & Siahpush, 2001; Dowd & Zajacova, 2007), UK (Chandola & Jenkinson, 2000), Denmark (Helvig-Larson, Kjøller & Thoning, 2003), Israel (Singh-Manoux, Dugravot, Shipley, Ferrie, Martikainen, Goldberg & Zins, 2007), the Netherlands (Mackenbach, Simon, Looman & Joung, 2003), Finland (Heistaro, Jousilahti, Lahelma, Vartiainnen & Puska, 2001) and Sweden (Burström & Friedland, 2001) which indicate that self-reported health is a remarkably good predictor of subsequent mortality. These studies employ data from large surveys of the population which ask a questions on health and link them to national registers of deaths for the individuals in the survey or to serious acute illness.

Burström and Friedlund (2001, p.836) found, using a study of 170 thousand respondents to the Swedish Survey of Living Conditions, “that poor self-rated health is a strong predictor of subsequent mortality in all sub-groups studied.”. They compared the mortality risks of persons reporting fair or poor health with those reporting good health using ratios of the rates of the two groups. For occupation groups the rate ratios varied between 1.1 and 2.2 for those with fair health and between 2.5 to 3.7 for those with poor health. Heistaro et al. (2001) carried out analysis in eastern Finland confirming that, adjusting for medical history, for factors associated with heart disease and strokes and for education, poor self-rated health was a robust predictor of mortality. In a Danish study Helwig-Larson et al. (2003) controlled for socioeconomic status, illness experience and life style variables and found a weaker self-reported health-mortality relationship for persons aged 56 or over. Franks et al. (2003) examined the self-reported health-mortality relationship from a different perspective. They built models to predict mortality outcomes in the 1997 US National Medical Expenditure Survey and found socioeconomic effects much reduced when self-reported health variables were introduced into the models, though they found differences between ages, ethnic groups and sexes remained. Compared with Whites, Blacks had higher hazard ratios and Latinos and others had lower, though there were differences by migrant status within groups. Singh and Siahpush (2001) find that “immigrant men and women had, respectively, an 18% and 13% lower risk of overall mortality than their US born counterparts”.

4
Several studies suggest there are complications in the self-reported health-mortality nexus. Franks et al. (2003) point to differences in the relationship between self-reported health and mortality for men and women. Women experience longer lives and lower mortality risks, adjusting for age, than men in most countries. Yet their self-reported illness rates, controlling for age, are similar to those of men in the UK (Weller 2006) and higher in South East Asia. There is evidence from surveys in South East Asia (Lutz, Samir, Khan, Scherbov & Leeson, 2007; Karcharnubarn, 2008) that women are significantly more likely to report poor health. Singh-Manoux et al. (2007) found that self-reported health is less able to predict mortality risk for middle aged individuals, while Dowd and Zajacova (2007) identified much greater relative risks for those in poor health in the top socioeconomic quartile than in the bottom.

People from different cultural backgrounds may report their health differently from other population subgroups and from each other in different places and at different times. Since there is potential for self-assessment to be affected by subjective factors, apparent differences in health between areas and population subgroups are perhaps due to varying interpretations of health (Bailis, Segall & Chipperfield, 2003) and, in terms of LLTI, of what may constitute a limiting and/or a long-term illness (Gooberman-Hill, Ayis & Ebrahim, 2003; Senior, 1998). Mitchell (2005) notes that self-reported poor health is influenced by expectation and comparison which themselves may be culturally determined. Whatever the health influence of ‘culture’ may be, significant differences have been found in self-reported morbidity by different socio-demographic groups in terms of gender and ethnicity (see Cavelaars, Kunst & Geurts, 1998; Curtis & Lawson, 2000; Franks et al., 2003; Harding 2003).

However, explicit tests of ethnic variation in the relationship between self-reported health-mortality or serious illness have not identified significant differences. McGee et al. (1999) used the National Health Interview Survey 1986-1994, linking records to the US Deaths Index to estimate rate ratios (good health outcomes to poor or fair health outcomes) for five racial/ethnic groups, controlling for age, number of bed days in hospital, number of visits to a physician and number of years of education. For men, rate ratios were 2.5 for Whites and 2.0 for Blacks and for women they were 2.3 and 1.9. The variation between racial/ethnic groups, controlling for health history and socio-demographic attributes, was small. Commentators have suggested differences in the way racial/ethnic groups interpret questions on health, but McGee et al. (1999, p.45) affirm that “whatever self-reported health was measuring, it was nevertheless a strong predictor of mortality among racial/ethnic groups we studied”. In a study of the relationship between self-rated health and subsequent serious illness, Chandola and Jenkinson (2000) examine the differences between four ethnic groups (White, Caribbean, Indian and Pakistani/Bangladeshi). The study was based on two British surveys, the Health Survey for England and
the Fourth National Survey of Ethnic Minorities. There are differences between ethnic groups in the odds of experiencing serious illness of persons with fair to very poor health compared with those reporting excellent or good health, but none of these differences are significant at the 95% level nor are they consistent across serious illnesses. Chandola and Jenkinson (2000, p156) conclude by stating that their results “did not find any evidence [that] associations of self-related health with other, more objective measures of morbidity significantly differ between ethnic groups”.

The relationship between self-reported health and mortality for geographical populations

Since the estimation of ethnic group mortality is to be made for areas, we need to understand the relationship between self-reported health and mortality for geographical populations. The geographical distributions of morbidity and mortality were compared by Rees (1993/94) by plotting the crude limiting long-term illness rate (1991 Census) against standardized mortality ratio (SMR) for counties in Great Britain. A moderate linear relationship was found but with residuals for counties in Wales, which had higher illness rates than predicted by the SMRs, and Scotland, which had lower illness rates than predicted by SMRs. Charlton, Wallace & White (1994) provide a full description of limiting long-term illness in Great Britain, based on the 1991 Census, identifying systematic differences between ethnic groups and sexes in their (directly) standardized illness rates: Whites, Chinese and Other Asian groups have lower than average rates, while the Black groups and South Asian groups have higher than average rates, with Pakistani and Bangladeshi groups reporting the highest rates. Charlton et al. (1994, Fig.6) extend the comparison of self-reported illness and mortality initiated by Rees (1993/94) by plotting the all-cause standardized mortality ratio for local authorities in England and Wales against the standardized long term illness ratio for men and for women aged under 75 in 1991. The correlations are high (0.80 for men and 0.82 for women) and the scatterplots reasonably linear. For local authorities, similar distributions of LLTI and mortality were also observed in 1991 by Bentham et al. (1995) and in 2001 by Bambra and Norman (2006). Mitchell (2005) has compared plots of male mortality, measured by life expectancy at birth, against directly standardized illness rates for local authorities in England, Scotland and Wales in both 1991 and 2001. He found differences in the relationship between the three countries but showed that they had narrowed. The 2001 relationships for the three home countries were different from those for 1991 because illness rates, controlling for age, were substantially higher in 2001. However, he argues that “it is more likely that this shift is explained by a change in the likelihood and meaning of reporting illness, than in the implication of morbidity for mortality, per se” (Mitchell 2005, p.307). Since O’Reilly, Rosato and Patterson (2005) also find differences in the relationship between self-reported health and mortality within each of the UK’s constituent countries, we report on the illness-mortality relationship in 2001 for all four home countries later in this paper.
What the evidence tells us

From a review of examples of ethnic population in several countries, we conclude as follows.

- International best practice in carrying out projections for racial/ethnic populations uses racial/ethnic specific mortality rates.
- No direct measures of racial/ethnic mortality are available in the UK which are not seriously biased or based on national samples which cannot be used to produce local measures. Some data are available by country of birth but country of birth differences may be different from ethnic group differences as the latter include second and later generations, descendants of immigrants.

From studies of individual health and mortality histories, we conclude as follows.

- Microdata studies find that self-reported health status is a strong predictor of subsequent mortality, but the relationship for men is different from that for women.
- Socioeconomic factors are important in explaining mortality variation across groups but self-reported health status still has a significant influence.
- There is variation between racial/ethnic groups in the self-reported health-mortality link but the differences were not significant.
- The first immigrant generation has better self-reported health and mortality than subsequent generations.

From studies of geographical populations, we conclude as follows.

- Studies have found moderate relationships between illness and mortality measures, although care is needed to control for socioeconomic deprivation and to measure the area-based relationships for different sub-sets of local areas in the UK (e.g. by home country).

These conclusions give us the confidence to explore the use of self-reported limiting long-term illness from the 2001 Census measured at local authority scale for ethnic groups to predict mortality levels by ethnic group.

Data used

The ethnic population data for local authorities

The United Kingdom is divided up for local administration into 434 lower tier areas, called local authorities (L.As) (see ONS 2008d for a comprehensive map). In the present study we merged two pairs of local authorities in England because of the small residential population of one of the pair (Isles of Scilly with Penwith and City of London with Westminster). The results are reported for 352 local areas in England and 432 in the UK.
Ethnicity is a debated concept. It is defined in the UK to self-reported identity, based on a mixture of race and national origins and associated traits. An ethnic group includes immigrants born outside their country of residence plus their offspring (second, third and subsequent generations) who still identify with their parents’ or grandparents’ ethnicity. In the UK census a question was asked in 1991 and 2001 in which respondents were asked to tick a box against an ethnic category or to write in a description in one of several write-in spaces. The classifications differ between the 1991 and 2001 Censuses with 2001 introducing four Mixed groups to reflect the direction that the population was moving (Bradford 2006).

Ethnic population data were extracted from the 2001 Census of Population in England, Wales, Scotland and Northern Ireland (full details are given in Rees and Wohland 2008). Table 1 shows the numbers recorded in the 2001 Census for each ethnic group in each country. The populations of Wales, Scotland and Northern Ireland are overwhelming White, while only 91% of England’s population was White and only 87% was White British. The largest ethnic minority group in England was the White Other group (1308 thousand people), the largest non-White group was the Indian group (1029 thousand) and the fastest growing was the Mixed group (Rees and Butt 2004).

[Table 1 about here]

The illness data

In the 2001 Census the following question was asked: “Do you have any long-term illness, health problem or disability which limits your daily activities or the work you can do? Include problems which are due to old age.” This information was coded into a limiting long-term illness variable (LLTI) and age by sex tables were produced for each UK local authority: Census Table S16 for all people in households and Table S65 for all people resident in communal establishments. These data were extracted using the CASWEB interface (CDU 2008). The age classification consisted of five year age groups from 20 to 24 to 90+ with a more detailed age breakdown below 20. We computed the prevalence rates of limiting long-term illness using data from the two tables.

The mortality data

Counts of deaths by all local authorities in England and Wales were supplied by the ONS Vital Statistics Branch in Newport, Wales. We used the data for 2001 from a longer time series for ages 0, 1-4, 5-9 to 80-84 and 85+. Equivalent information was obtained from the General Register Office Scotland (GROS) and from the Northern Ireland Statistics and Research Agency (NISRA). Mortality rates by single year of age (SYA) to age 100+ were downloaded from the Government Actuary Department’s database of
national life tables (GAD 2008). National SYA mortality rates were combined with the local mortality information to estimates local SYA rates and hence local life tables.

The population estimates

Mid-year population estimates by SYA to age 85+ for local authorities for 2001 were sourced from ONS (England and Wales), GROS (Scotland) and NISRA (Northern Ireland). SYA populations from the 2001 Census (Table ST01) from 85 to 100+ were controlled to the local 85+ population estimates to estimate SYA population estimates to age 100+.  

The estimation of mortality as a function of self-reported illness

The aim of the analysis is to develop benchmark estimates for 2001 of mortality rates by ethnic group in the UK for local areas. These estimates are used to generate, using life tables, the survivorship probabilities needed as input to an ethnic population projection model for the UK (Rees et al. 2008). Two methods are used to estimate ethnic mortality rates. The first method uses an empirical relationship between illness and mortality for local areas to derive ethnic group Standardized Mortality Ratios (SMRs) from ethnic group Standardized Illness Ratios (SIRs) derived from the 2001 Census. We call this the SIR method. The second method uses the geographical distributions of ethnic groups as measured in the 2001 Census to produce a weighted national average set of ethnic mortality rates. These UK rates are used with the local all group mortality rates to produce local estimates of ethnic mortality. We call this the GWM or Geographically Weighted Model. This method is discussed later in the paper.

The sequence of computations in the SIR method is as follows. Standardized Illness Ratios (SIRs) are computed, using 2001 Census data for all local authorities in the UK for the whole population (aggregated over ethnicity). These are regressed against local authority SMRs computed from deaths and population data for 2001. Regression relationships for three groupings of local authorities – by home country, by ethnic minority population share and by location in northern or southern England – are compared and one set of results chosen. SIRs are computed using 2001 Census data for each ethnic group in all local authorities. Where there are insufficient numbers ill or resident in a particular ethnic group for reliable estimation of local ethnic-specific SIRs, estimates are made through multiplying national ethnic specific SIRs by the local all group SIR divided by the UK mean. Then the all group regression intercept and slope parameters are used to generate ethnic-specific SMRs for each local area. Ethnic group mortality rates by age are estimated by multiplying the all group age-specific rates by the ratio of ethnic-specific SMRs to the all group SMR. These ethnic specific mortality rates by age for each local area are then adjusted so that they produce the observed all group number of deaths by age in 2001. The resulting
mortality rates are then input to life table routines to generate life tables for all ethnic groups in each local
authority, from which survivorship probabilities can be extracted for use in population projection. The
analysis is carried out for men and women separately. We now specify this model formally.

**The standardized illness ratios for LAs**

The SIR for the UK was computed as follows. The age specific illness (prevalence) rate for the UK was
given by:

$$r_{ixg}^U = \frac{\sum_{c \in U} \left[ P_{ixg}^c (H) + P_{ixg}^c (C) \right]}{\sum_{c \in U} \left[ P_{ixg}^c (H) + P_{ixg}^c (C) + P_{ixg}^U (C) + P_{ixg}^U (G) \right]}$$  \hspace{1cm} (1)

where the variable P represents the population recorded as residents in the 2001 Census, c is the index for
home country within the UK, I indexes people with limiting long term illness, N indexes people who do
not have limiting long term illness, x represents age group, g represents gender, H refers to residents in
households, C refers to residents in communal establishments, U refers to the United Kingdom (the
standard population) and r refers to prevalence rate of limiting long term illness.

These national prevalence rates are then applied to the local number of residents in each age group to
compute the expected number of people reporting limiting long term illness. The ratio of the observed
number reporting illness to the expected number then gives the SIR for each gender g for local area i in
country c.

$$SIR_{ixg}^{(c)} = \frac{100 \left( P_{ixg}^{(c)} (H) + P_{ixg}^{(c)} (C) \right)}{\sum_x r_{ixg}^U \left( P_{ixg}^{(c)} (H) + P_{ixg}^{(c)} (C) \right)}$$  \hspace{1cm} (2)

The asterisk subscript indicates summation over age x in the two numerator variables. Equation (2) is the
illness equivalent to the Indirect SMR. We use equation (2) again to compute SIRs for ethnic groups,
where numbers allow. The Indirect SIR has the advantage that it can be computed for smaller populations
where the local age-specific rates, needed for the Direct SIR, are not reliable.

**The standardized mortality ratios for LAs**

Standardized Mortality Ratios (SMRs) are computed for the all group populations for local authorities in
UK using the indirect method:

$$SMR_{ixg}^{(c)} = 100 \times \left( \frac{D_{ixg}^{(c)}}{\sum_x m_{ixg}^U \cdot p_{ixg}^{(c)}} \right)$$  \hspace{1cm} (3)

where $D_{ixg}^{(c)}$ are the deaths of residents in local authorities i in country c and of gender g in calendar year
2001, $m_{ixg}^U$ are the mortality rates for age x and gender g in the standard population U, the United
Kingdom, and $P_{xg}^{(c)}$ are the 2001 mid-year estimate populations in local authority $i(c)$, age $x$ and gender $g$.

The relationship between SIR and SMR for LAs

Figure 1 graphs SMR against SIR for three different partitions of the local authority data set for women and men. Table 2 provides the coefficients for the regression lines depicted in the graphs. How good a predictor of a local authority’s SMR is its SIR? The goodness of fit ($r$) varies from a low of 0.40 for females in Northern Ireland to a high of 0.88 for females in Wales; on average it is around 0.72 but higher for males than females. About half the variation in SMRs across local authorities is associated with variation in self-reported limiting long-term illness. Slope coefficients are all well below one, indicating that there is regression towards the mean: areas with higher than average SIRs also experience higher than average SMRs but these are closer to the mean; areas with lower than average SIRs also exhibit lower than average SMRs but these are closer to the mean.

[Figure 1 about here]
[Table 2 about here]

How might we explain this regression to the mean effect? Self reported illness affects around 18-20% of the population whereas mortality affects only 0.8-1.2% of the population. Both illness and mortality are exponentially associated with age but the mortality curve is much steeper. Illness rates are higher in the working ages relative to the mean than are mortality rates. We know that working age SIRs and SMRs have higher variability between areas and are more closely associated with deprivation indicators than old age SIRs or SMRs (Brown and Rees 2006). Because of this composition effect, SIRs have a wider variance. The regression slopes vary between home nation sets of local authorities (Figure 1a, 1b). The England slopes are close to the UK slopes; Scotland has considerably steeper slopes than England; Wales and Northern Ireland have gentler slopes, indicating stronger regression to the mean. The slopes for men are steeper than for women with mortality and illness ranges greater for males.

Are there other partitions of the LA data set beside the UK home-nations that produce significant differences the SIR-SMR relationship? Figures 1(c) and 1(d) show what happens for England when we divide LAs into those with above average ethnic minority shares in their population and those with below average shares. Might there be different relationships because of ethnic compositions of the population? The results suggest not: the two sets give almost identical coefficients. Figures 1(e) and 1(f) test the proposition that LAs in northern England show a different SIR/SMR relationship from LAs in southern
England (using the North-South definition of SASI 2007). The South LAs regression slopes are less steep but the differences between North and South are smaller than between home countries. In conclusion, we use the different relationships between SIR and SMR for each home nation. The next step was to estimate SIRs for ethnic groups in local areas using 2001 Census data.

**Standardized illness ratios for ethnic groups in LAs**

The 2001 Census provides information on both resident population and limiting long term illness for ethnic groups by local area. The SIRs for ethnic groups in local authorities in England and Wales are computed thus

\[
SIR_{eg}^{(E)} = 100 \times \left( \frac{i_{eg}^{(E)}}{\sum_x r_x^{(U)} \cdot p_{exg}^{(E)}} \right)
\]

where

- \(i_{eg}^{(E)}\) = people of ethnic group in local areas i in England (E) of gender g who report limiting long term illness
- \(p_{exg}^{(E)}\) = people of ethnic group e in age group x and gender g in local area i in England (E)
- \(r_x^{(U)}\) = limiting long term illness prevalence rate for persons in age group x of gender g in the UK

It would be possible to compute a directly standardized illness ratio but the small numbers for many local areas and groups make the local rates unreliable. However, use of the indirectly estimated SIR also runs into these small number problems and results in extreme values for many SIRs. Inspections of the results suggested that a threshold needed to be set for use of SIR: there should be at least 10 persons reporting limiting long-term illness in each LA-gender-ethnic group and at least 100 persons in the population of that group. Figure 2 shows the impact of this rule for women from selected ethnic groups in England. The dark shade indicates LAs with above threshold ill persons and population at risk numbers; the light shade show LAs where the ethnic group numbers fall below the thresholds. For the White group all LAs are above the thresholds; for the Chinese group a majority of LAs have above threshold numbers; the Caribbean and Pakistani groups are much more clustered and only urban LAs have above threshold numbers.

[Figure 2 about here]

So how can we estimate ethnic group SIRs for the light shaded areas? We considered the following simple alternatives for estimating SIRs for small threshold local areas: (1) use the *national* ethnic group...
SIR in below threshold LAs, (2) use the local all group SIR in below threshold LAs and (3) use a mix of the national ethnic group SIR and the local all group SIR. Formally, the mixed models is

\[
SIR_{eg}^{(c)} = SIR_{eg}^c \times \left[ \frac{SIR_{eg}^{(c)}}{SIR_{eg}^c} \right]
\]  \hspace{1cm} (5)

where the asterisk indicates summation over the index replaced. Equation (5) assumes independence of a local effect and a national effect. To gauge the accuracy of each of these simple models we computed SIRs for those local authorities with above threshold numbers. The national model is a very poor estimator and so was not used further. We chose to use the mixed model rather than the local model to estimate SIRs for local-gender-ethnic groups on the basis of a slightly better performance. Figure 3 graphs the mixed model results (y-axes) against the SIRs computed using observed numbers ill and by age for ethnic groups. For the largest and most homogeneous groups the model fits well except for the Pakistani group; the fits are poorer for the smaller groups.

[Figure 3 about here]

**The distribution of SIRs for ethnic groups across LAs**

For England only, Figure 4 displays histograms of the LA distribution of SIRs for males and females for each of the 16 ethnic groups. White British SIRs cluster around the UK mean of 100 with a slightly lower average and comparable distributions for men and women. The White Irish SIRs are similar but slightly higher. The White Other group has a distribution with a majority of LAs below the UK average. The Mixed White and Black Caribbean and Mixed, White and Black African groups exhibit worse illness distributions than White groups with higher than UK averages. The Mixed, White and Asian and Mixed, Other Mixed have slightly higher than average SIRs. The Asian or Asian British SIRs have female SIRs higher than male SIRs. This suggests that Asian men are more reluctant to report limiting long term illness than Asian women. Indian men have about average SIRs while Indian women have an average 23 points higher. Pakistani and Bangladeshi men and women both report significantly high SIRs. Other Asian females are above average. Black or Black British groups have contrasting experiences: the Black Caribbean and the Other groups report more illness than average, while Africans report lower illness. The Chinese have the lowest SIR of any ethnic group, while the SIRs of the Other Ethnic group are also below average.

[Figure 4 about here]

**Generation of SMRs and full life tables for LAs, ethnic groups and genders**
The next step is to compute an estimate for the SMR for each ethnic group in local authorities using the estimated SIRs and the regression relationships for the whole populations of local areas reported earlier in the paper. The general relationship used is:

$$_SM^{(c)}_{eg} = a_g^c + b_g^c \times SIR^{(c)}_{eg}$$  \hspace{1cm} (6)$$

where $a_g^c$ is the regression intercept for country c and gender g and $b_g^c$ is the regression slope for country c and gender g (Table 2 reports the numerical values). We use these SMRs and the age-specific mortality rates for LAs to produce estimates of ethnic group mortality rates for LAs:

$$m^{(c)}_{exg}(1) = \left( \frac{SMR^{(c)}_{eg}}{100} \right) m^{(c)}_{xg}$$  \hspace{1cm} (7)$$

where

$m^{(c)}_{exg} = \text{the mortality rate for local area } i \text{ in country } c \text{ for ethnic group } e, \text{ age } x \text{ and gender } g$

$m^{(c)}_{xg} = \text{the mortality rate for local area } i \text{ in country } c, \text{ age } x \text{ and gender } g$

The all group mortality rates are factored up or down by the ratio of the ethnic group SMR to the all group SMR. We assume, in effect, that each group’s mortality rate schedule by age follows the all group structure.

These first estimates may not be consistent with the total number of deaths in a local area so we introduce an adjustment:

$$m^{(c)}_{exg}(2) = m^{(c)}_{exg}(1) \times \left[ \left( m^{(c)}_{xg} P^{(c)}_{xg} \right) / \sum_e m^{(c)}_{exg}(1) P^{(c)}_{exg} \right]$$  \hspace{1cm} (8)$$

These mortality rates by ethnicity, age and gender are fed into life tables to generate the survivorship probabilities by period-cohort needed for projecting ethnic group population. Before reviewing the results of the estimation procedures based on SIRs, we first review an alternative and simpler method for estimating mortality rates by ethnicity for local areas.

**The estimation of mortality rates by geographical weighting**

We know that the spatial distributions of the different ethnic groups across local authorities in the UK are very clustered. Only the White British group is found everywhere. Assume to begin with that each ethnic group has the same mortality rate as the all group population in a local area. We can then form a sum of these local rates weighted by the population of the ethnic group in the local area. If a group is clustered in high mortality local areas this will mean a high national mortality rate for that ethnic group. Similarly, if a group is clustered in low mortality areas, the estimated national rate for the ethnic group will be low. A second step is to reintroduce the estimated national mortality rates for the ethnic group locally and adjust
them so that the local ethnic group mortality rates are consistent with the all group mortality rates. Details of this method are given in Rees and Wohland (2008).

Results

Comparison of methods

How do the results of these two methods compare? To answer this question we focus on life expectancy at birth, because this uses information from all age specific mortality rates. Comparison of the means showed that the two methods differ significantly for 12 of 16 male groups and 14 of 16 female groups, using Student’s t test. So our choice of method matters.

Are the differences systematic? Figure 5 suggests they are. On the graph we plot the SIR based $e_0$ values on the X axis and GWM based $e_0$ values on the Y axis. For women the correlation across 16 groups is 0.83; while for men it is only 0.63. The regression slopes are 0.43 for women and 0.42 for men. In other words the GWM method produces a distribution much closer to the national average than the SIR method. The ranges are 4.8 years for women and 5.4 years for men using the SIR method, while they are only 2.3 for women and 3.8 for men using the GWM method.

[Figure 5 about here]

Box plots in Figure 6 help us understand the variation between ethnic groups across local authorities in England. It is clear that the GWM method produces lower variability distributions. For example, there are no outliers in the female graph and only low outliers in the male graph. The graphs for life expectancies generated by the SIR method are more variable and have both upper and lower outliers. These comparisons persuade us that the SIR based estimates are more plausible. They reflect real differences between groups and avoid over-smoothing.

[Figure 6 about here]

Results of SIR method

Here we discuss the patterns revealed by the chosen SIR method. The population- weighted mean life expectancies for local authorities in England are reported in Table 3. The all group mean is placed in the table for reference. The White British group life expectancies are close to the mean, slightly below the all group mean for men and slightly above for women. The Chinese group life expectancies are highest for
both men and women. Above the all group mean for men and women are the Other White and Other 
Ethnic and Black African men are slightly above the all group men. The Indian group has life 
expectancies close to the all group average for men but well below average life expectancies for women. 
We already noted that Indian men report lower rates of limiting long-term illness, relative to the all group 
average than women. The lowest life expectancies are experienced by Bangladeshis, Pakistanis, the Other 
Black group and the White and Black Caribbean group. Still below but closer to the All Group mean are 
the White and Black African, White and Asian, White Irish, Black Caribbean and Other Mixed groups.

[Table 3 about here]

The spatial patterns of life expectancies for England

We now describe our estimates of life expectancy at birth for men and women for each of the ethnic 
groups across all local authorities in England. Ethnic life expectancies for LAs in Wales, Scotland and 
Northern Ireland are reported in Rees and Wohland (2008).

Figure 7 captures the spatial variation for women in each ethnic group for England. The spatial patterns of 
life expectancy of men and women are very similar (see Rees and Wohland 2008 for maps for men). Life 
expectancies for women are higher than for men: the gaps range from 3.8 years (Indians) to 5.4 years 
(White Irish). The lowest differences are for the Asian groups; the highest differences are for the Irish and 
Mixed groups. The maps use a simple shading classification designed to pick out the most favored areas 
(dark grey shade), middle areas (mid-grey shade) and least favored areas (light grey shade). The highest 
25% of areas (108 LAs) are those that have \( e_0 \) values above the upper quartile of the UK distribution, 
which are 77.2 years for men and 81.2 years for women. The values of \( e_0 \) for the lowest 25% of areas lie 
below the lower quartile of the UK distribution (108 LAs), which are 74.5 years for men and 78.9 years 
for women. The 50% of areas (216 LAs) that lie within the inter-quartile range are shaded mid-grey.

[Figure 7 about here]

The following features stand out from the maps of life expectancy.

- There is a gradient from higher life expectancies in South and East England to lower expectancies 
in Northern England.
- This gradient is modified by urban/rural status of local authorities. Life expectancies in rural 
areas are higher than expectancies in urban areas. So, in Northern England there is a band of rural
local authorities running from North Yorkshire to Cumbria which have favored life expectancies (Brown and Rees 2006). In South and East England there are local authorities within urban areas which have lower life expectancies, particularly in Inner London and in the eastern LAs of the London capital region.

- Four ethnic groups stand out as having most areas in the top quartile of the distribution: the Chinese, Black African, Other Ethnic and White Other groups, although in Northern England and in cities in South and East England, there are local authorities in the middle band.

- Four ethnic groups stand out as having a large number of local areas in the bottom quartile: the Mixed White and Black Caribbean, Pakistani, Bangladeshi and Black Other groups.

- The remaining groups, White British, White Irish, Mixed White and Black African, Mixed White and Asian, Mixed Other Mixed, Indian, Other Asian and Black Caribbean, have a mixture of high, middle and low life expectancies.

*Towards an explanation for the spatial patterns of ethnic life expectancy*

There is an extensive literature that explores explanations for spatial variations in mortality for local populations (Gatrell 2002). The variations are seen as a product of personal characteristics of group members, of the collective population attributes of the local area (“the neighborhood effect”) and the nature of the physical and man-made environments people inhabit. The principal factors at work which vary spatially are: socioeconomic deprivation, family and household structures, life style (smoking, excess alcohol consumption, diets), air pollution (higher in urban areas), industrial legacy (e.g. coal-mining, asbestos manufacture), the health care available and inequalities in health care access (“the postcode lottery”) and factors influencing the spread of infections. Other factors include the influence of migration (of those in good and poor health) and the influence of inequalities in income and welfare (relative deprivation) with links to stress factors. An explanation of the variation between ethnic groups across UK space in mortality would seek to look at their experience/exposure to each of these risk factors. There are also a number of conditions specific to people with particular genes concentrated in certain ethnic groups (e.g. sickle-cell anemia). Consideration of this set of factors will shape follow-on work on our results.

Having reviewed the results of our chosen mortality estimation method in this section, we summarize and reflect on our findings in the final section of the paper.
Discussion and conclusions

In this paper we have produced estimates of the mortality experience of the UK’s ethnic groups in local authorities for all four home countries and presented results for England LAs. To our knowledge no equivalent estimates have been produced hitherto.

Estimates were prepared using two methods: the first inferred ethnic mortality from self-reported limiting long-term illness; the second inferred ethnic mortality by using ethnic populations to re-weight local area mortality to yield estimates of national and local ethnic mortality. The first method built on the repeated finding of many micro-data studies that self-reported health and illness assessments were good predictors of subsequent mortality. We analyzed the association between limiting long-term illness and mortality using indicators for local areas and found moderately high correlations for Great Britain (the associations for Northern Ireland were still positive but weaker). The slopes of the linear regression of SMRs as a function of SIRs produced slope coefficients which indicated that the spatial variation of SIRs was shrunk when converted into SMRs.

We then made an assumption that the regression equation between SIRs and SMRs for the whole population could be applied to each ethnic group. Studies of the self-reported health-mortality relationship found no significant differences between ethnic groups. Our experiment in dividing local authorities in England into high and low ethnicity sets found no significant difference in regression coefficients (Table 2). We did, however, find considerable differences between local authorities in the four home countries of the UK and therefore used separate sets of regression equations. Any errors associated with this assumption were in part mitigated by adjusting the resulting local mortality rates to be consistent with mortality rates for the whole population of the local area.

There were significant differences between the SIR and GWM estimates. Although the two methods produced moderately correlated results, the SIR method produced much more variation between groups than the GWM method. We chose to use the SIR based estimates in subsequent work because we believed that the prevalence of limiting long-term illness would have an important influence on subsequent mortality risk.

The estimates were developed for the year 2001 where we could link illness information from the 2001 Census to mortality data for the calendar year. Having estimated SMRs for each ethnic-gender group in each local area, we used local life tables for the whole population to generate ethnic-gender specific full
life tables with one extension. We computed survivorship probabilities for single year period-cohorts for
input to a projection model for ethnic groups in all UK local authorities. These will be updated using time
series of LA life expectancies for input to our planned projections.

Better estimates of ethnic group mortality will only come if an ethnicity indicator is added to the mortality
babies born in England, Wales and the Isle of Man to create an NHS Numbers for Babies (NN4B) dataset
from which infant mortality estimates by ethnicity have been made. If this system of recording ethnicity
was extended to all mortality occurrence records, then direct measurement of ethnic mortality would be
possible.

References


Briefing 2006/22, November 2006. Data Management and Analysis Group, Greater London
Authority, London. Online at: http://www.london.gov.uk/gla/publications/factsandfigures/dmag-

Briefing 2007/14, July 2007. Data Management and Analysis Group, Greater London Authority,
London. Online at: http://www.london.gov.uk/gla/publications/factsandfigures/DMAG-Briefing-

Bambra, C. & Norman, P. (2006). What is the association between sickness absence, morbidity and
mortality? Health and Place, 12(4), 728-733.

its associations with mortality and indicators of social deprivation. Journal of Epidemiology and
Community Health 49, S57-S64.


February 2009.

of Bradford Metropolitan District Council, Policy and Research Unit: Bradford.

of Bradford Metropolitan District Council, Policy and Research Unit: Bradford.


among adults in lower as well as in higher social classes. Journal of Epidemiology and Community
Health, 55, 836-840.

Cavelaars, A., Kunst, A. & Geurts, J. (1998). Differences in self-reported morbidity by educational level:
a comparison of 11 Western European countries. Journal of Epidemiology and Community Health, 52,
219-27.


22

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<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>England and Wales</td>
<td></td>
<td>Scotland</td>
<td></td>
</tr>
<tr>
<td>White: British (WBR)</td>
<td>42747.1 (86.99)</td>
<td>White (WHI)</td>
<td>4960.3 (97.99)</td>
</tr>
<tr>
<td>White: Irish (WIR)</td>
<td>624.1 (1.27)</td>
<td>Indian (IND)</td>
<td>15.0 (0.30)</td>
</tr>
<tr>
<td>White: Other White (OWH)</td>
<td>1308.1 (2.66)</td>
<td>Pakistani and other South Asians (PAS)</td>
<td>40.0 (0.79)</td>
</tr>
<tr>
<td>Mixed: White and Black Caribbean (WBC)</td>
<td>231.4 (0.47)</td>
<td>Chinese (CHI)</td>
<td>16.3 (0.32)</td>
</tr>
<tr>
<td>Mixed: White and Black African (WBA)</td>
<td>76.5 (0.16)</td>
<td>Others (OTH)</td>
<td>30.4 (0.60)</td>
</tr>
<tr>
<td>Mixed: White and Asian (WAS)</td>
<td>184.0 (0.37)</td>
<td>Total</td>
<td>5062.0 (100)</td>
</tr>
<tr>
<td>Mixed: Other Mixed (OMI)</td>
<td>151.4 (0.31)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian or Asian British: Indian (IND)</td>
<td>1028.5 (2.09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian or Asian British: Pakistani (PAK)</td>
<td>706.5 (1.44)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian or Asian British: Bangladeshi (BAN)</td>
<td>275.4 (0.56)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian or Asian British: Other Asian (OAS)</td>
<td>237.8 (0.48)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black or Black British: Black Caribbean (BCA)</td>
<td>561.2 (1.14)</td>
<td></td>
<td></td>
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<tr>
<td>Black or Black British: Black African (BAF)</td>
<td>475.9 (0.97)</td>
<td></td>
<td></td>
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<tr>
<td>Black or Black British: Other Black (OBL)</td>
<td>95.3 (0.19)</td>
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<td>Chinese or Other Ethnic Group: Chinese (CHI)</td>
<td>220.7 (0.45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinese or Other Ethnic Group: Other Ethnic Group (OET)</td>
<td>214.6 (0.44)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49238.8 (100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>1685.3 (100)</td>
</tr>
</tbody>
</table>

Source: UK Census 2001, Office for National Statistics
Table 2
The parameters for the linear regressions of SMR as a function of SIR

<table>
<thead>
<tr>
<th>Local area group</th>
<th>Women</th>
<th></th>
<th></th>
<th>Men</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>a</td>
<td>95% confidence interval (a)</td>
<td>b</td>
<td>95% confidence interval (b)</td>
<td>r</td>
</tr>
<tr>
<td>England (n=352)</td>
<td>0.71</td>
<td>52.1</td>
<td>47.4-56.9</td>
<td>0.48</td>
<td>0.43-0.53</td>
<td>0.79</td>
</tr>
<tr>
<td>Wales (n=22)</td>
<td>0.88</td>
<td>60.5</td>
<td>49.7-71.4</td>
<td>0.37</td>
<td>0.28-0.46</td>
<td>0.75</td>
</tr>
<tr>
<td>Scotland (n=31)</td>
<td>0.83</td>
<td>43.9</td>
<td>26.9-60.8</td>
<td>0.64</td>
<td>0.48-0.80</td>
<td>0.87</td>
</tr>
<tr>
<td>Northern Ireland (n=26)</td>
<td>0.40</td>
<td>71.2</td>
<td>40.6-101.8</td>
<td>0.26</td>
<td>0.01-0.51</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Notes:
1. n = number of local areas, a = intercept, b = slope.
2. The equation $SMR = a + b \times SIR$ was fitted to three different partitions of Local Areas:
   - the regression coefficients were calculated for LAs for each home nation England, Wales, Scotland and Northern Ireland and by gender, females and males;
   - the regression coefficients were calculated for LAs and by gender with high ethnic minority/low ethnic minority LAs UK, where high ethnic minority means non white population is more than 8.2 % of the population, 107 of the 108 LAs are in England;
   - the regression coefficients were calculated for LAs and by gender for North and South England defined by SASI (2007).
**Table 3**
The ranking of mean life expectancy at birth (e0) and median, minimum (Min) and maximum (Max) e0 for ethnic groups, men and women, England, 2001, calculated with the SIR method

<table>
<thead>
<tr>
<th>Rank</th>
<th>Ethnic group</th>
<th>Women e0</th>
<th></th>
<th></th>
<th>Men e0</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Mean) (Median)</td>
<td>Mean</td>
<td>Min</td>
<td>Max</td>
<td>Rank</td>
<td>(Mean)</td>
<td>Min</td>
</tr>
<tr>
<td>1</td>
<td>Chinese</td>
<td>82.1</td>
<td>82.3</td>
<td>77.8</td>
<td>1</td>
<td>Chinese</td>
<td>78.1</td>
</tr>
<tr>
<td>2</td>
<td>Other Ethnic</td>
<td>81.5</td>
<td>81.8</td>
<td>77.9</td>
<td>2</td>
<td>Other White</td>
<td>76.9</td>
</tr>
<tr>
<td>3</td>
<td>Other White</td>
<td>81.3</td>
<td>81.2</td>
<td>76.7</td>
<td>3</td>
<td>Other Ethnic</td>
<td>76.2</td>
</tr>
<tr>
<td>4</td>
<td>White British</td>
<td>80.5</td>
<td>80.7</td>
<td>77.3</td>
<td>4</td>
<td>Black African</td>
<td>76.1</td>
</tr>
<tr>
<td></td>
<td>(80.7)</td>
<td>(80.7)</td>
<td>83.6</td>
<td>(80.7)</td>
<td></td>
<td>(77.3)</td>
<td>(81.9)</td>
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<tr>
<td></td>
<td>All groups</td>
<td>80.5</td>
<td>80.7</td>
<td>77.3</td>
<td>5</td>
<td>White British</td>
<td>75.9</td>
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<tr>
<td>5</td>
<td>Black African</td>
<td>80.4</td>
<td>80.7</td>
<td>76.6</td>
<td>6</td>
<td>69.0</td>
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<tr>
<td>6</td>
<td>White Irish</td>
<td>80.3</td>
<td>80.6</td>
<td>77.2</td>
<td>7</td>
<td>White-Asian</td>
<td>75.2</td>
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<tr>
<td>7</td>
<td>White-Asian</td>
<td>80.0</td>
<td>80.3</td>
<td>74.5</td>
<td>8</td>
<td>White-Asian</td>
<td>75.1</td>
</tr>
<tr>
<td>8</td>
<td>Other Mixed</td>
<td>79.9</td>
<td>80.2</td>
<td>75.2</td>
<td>9</td>
<td>Other Asian</td>
<td>74.9</td>
</tr>
<tr>
<td>9</td>
<td>Other Asian</td>
<td>79.5</td>
<td>79.8</td>
<td>76.2</td>
<td>10</td>
<td>Other Mixed</td>
<td>74.6</td>
</tr>
<tr>
<td>10</td>
<td>White-Black</td>
<td>79.5</td>
<td>79.9</td>
<td>76.2</td>
<td>11</td>
<td>Black Caribbean</td>
<td>74.4</td>
</tr>
<tr>
<td>11</td>
<td>African</td>
<td>79.3</td>
<td>79.7</td>
<td>75.7</td>
<td>12</td>
<td>White-Black Caribbean</td>
<td>74.2</td>
</tr>
<tr>
<td>12</td>
<td>Black Caribbean</td>
<td>79.1</td>
<td>79.6</td>
<td>75.8</td>
<td>13</td>
<td>White Black Caribbean</td>
<td>73.4</td>
</tr>
<tr>
<td>13</td>
<td>White Black</td>
<td>78.7</td>
<td>78.3</td>
<td>75.1</td>
<td>14</td>
<td>Other Black Caribbean</td>
<td>73.4</td>
</tr>
<tr>
<td>14</td>
<td>Other Black</td>
<td>78.5</td>
<td>79.2</td>
<td>75.3</td>
<td>15</td>
<td>Other Black Caribbean</td>
<td>72.7</td>
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<tr>
<td>15</td>
<td>Bangladeshi</td>
<td>77.7</td>
<td>78.6</td>
<td>74.5</td>
<td>16</td>
<td>Pakistani</td>
<td>72.7</td>
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<tr>
<td>16</td>
<td>Pakistani</td>
<td>77.3</td>
<td>78.3</td>
<td>74.2</td>
<td></td>
<td>Bangladesh</td>
<td>72.7</td>
</tr>
</tbody>
</table>
Figure 1: The relationships between SIR and SMR in UK local authorities by gender: for all local authorities in the UK and by countries, (a) females and (b) males, for local authorities in the UK with above and below average shares of ethnic minority groups (c) females and (d) males, for local authorities in Northern and Southern England (e) females and (f) males. Regression results are presented in Table 2.
Figure 2: Local areas with above and below threshold numbers of people, Women, selected ethnic groups, 2001 Census, England.
Figure 3
A comparison of SIRs computed using directly observed illness and population with SIRs produced by combining national SIRs for ethnic groups with all group SIRs for local areas, ethnic groups, England 2001, women
Note: The plots variables are: x=good original data, y= models, ×= mixed model, ○ = local data as model
Figure 4
The distribution of SIRs for local areas for ethnic groups, England, 2001,
Notes: Grey bars = men, solid bars= women; horizontal axis = SIR (100=UK mean), vertical axis = number of local authorities, numbers in right corner of each graph is the mean SIR of corresponding ethnic group for women (w) and men (m)
Figure 5
A graph comparing mean life expectancies at birth estimated using the Standardized Illness Ratio (SIR) and Geographical Weighted Model (GWM) methods for ethnic groups in England by gender, 2001.
Figure 6
Box plots for life expectancies for 16 ethnic groups in England, women and men, using the Standardized Illness Ratio (SIR) and Geographical Weighted Model (GWM) methods, 2001. See table 1 for group abbreviation.
Figure 7: Maps of life expectancy at birth, for 16 ethnic groups, England, females, 2001

- White British
- White Irish
- White Other
- Mixed, White and Black Caribbean
- Mixed, White and Black African
- Mixed, White and Asian
- Mixed, Other Mixed
- Asian or Asian British: Indian
- Asian or Asian British: Pakistani
- Asian or Asian British: Bangladeshi
- Asian or Asian British: Other Asian
- Asian or Asian British: Other Caribbean
- Black or Black British: African
- Black or Black British: Other
- Chinese
- Other Ethnic Group

Legend:
- Dark grey: >= 81.17 to <85.86
- Light grey: 78.91 to <81.17
- Medium grey: >= 73.77 to <78.91